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NEUROLINGUISTICS

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Definition

Neurolinguistics is the study of language-brain relations. Its final goal is the comprehension and explanation of the neural bases for language knowledge and use. Neurolinguistics is by its nature an interdisciplinary enterprise, and straddles the borders between linguistics and other disciplines that are connected to the study of the mind/brain (mainly cognitive psychology, neuropsychology and cognitive neuroscience). When approached from the point of view of the neurosciences, neurolinguistics focuses on how the brain behaves in language processes, both in healthy and pathological conditions; conversely, from a linguistics standpoint, neurolinguistics aims at clarifying how language structures can be instantiated in the brain, i.e. how patterns and rules exhibited in human languages are represented and grounded in the brain. In addition, neurolinguistics has a fundamental clinical impact for assessment and treatment of patients suffering from aphasia and other language pathologies.The field was officially opened up by the nineteenth-century neurologist Paul Broca with his observations of the correlation between language disturbance and brain damage. Since then, over 100 years of investigation into the organization of language in the brain were based on a lesion-deficit approach, in a localizationist perspective. The significance of a brain area was deduced through observation of deficits following a lesion to that brain region, and the exact localization of the lesion was verified through post-mortem examination. The aphasiological era developed a functional model of language production and comprehension that highlighted the Jan-Ola Östman&JefVerschueren
Handbook of Pragmatics (2012)

 Role of frontal and temporal regions (and connections between them) in the left.Hemisphere, a model that has informed diagnosis and research up to date. The state of knowledge began to change in the 1990s, with the advent of new methodologies for the functional exploration of the living brain. Today it is possible to identify the cerebral regions involved in the on-going performance of a specific linguistic task, and to relate brain activity to specific processing stages unfolding over time. With the contribution of functional neuroimaging and neurophysiology techniques, along with significant advances in clinical investigations, the field of neurolinguistics has substantially broadened. On the one hand, the original model of language organization in the brain is currently undergoing a process of revision, which emphasizes the role of distributed cerebral networks, rather than specific isolated areas, with differences in regional involvement and relative order of recruitment related to specific language sub-functions. On the other hand, scholars have started to investigate subtler questions than the production and comprehension dichotomy, approaching the representation of components such as phonology, syntax, semantics, and more recently pragmatics. While the field is relatively old and can be traced back to the nineteenth century, the term 'neurolinguistics' is quite recent. During the aphasiological era, what we now call neurolinguistics was entrenched in the province of neurology, thus lacking a specific characterization. Only after the late 1960s the study of language-brain relations attracted the linguists' interest, promoting the circulation of the term. Roman Jakobson was probably the first linguist to realize the potential relevance of neurolinguistics research for linguistic theories. Jackobson pointed out the importance of aphasia for understanding how language is instantiated in the healthy brain, and for confirming or disconfirming grammatical models stemming from theoretical linguistics (Jakobson 1941). The year 1985 witnessed the birth of the Journal of Neurolinguistics, presented as "the first and only journal that bears the name of this relatively new but fast developing field called "NEUROLINGUISTICS" and "the only journal concerned with the interface of neurology and linguistics, an interdisciplinary realm of specialization that takes upon itself the exploration of brain function in language behavior and experience" (Whitaker 1985). Nowadays the term neurolinguistics has become popular and stands aside other labels, among which "neuroscience of language" and "neurobiology of language", depending on the emphasis placed either on the linguistic or on the neuroscientific perspective.

Keywords: Neuroscience, Paul-Broca, aphasiological, lesion- deficit, neuroimaging, neurolinguistics.

History

Neurolinguistics is historically rooted in the development in the 19th century of aphasiology, the study of linguistic deficits (aphasias) occurring as the result of brain damage. Aphasiology attempts to correlate structure to function by analyzing the effect of brain injuries on language processing. One of the first people to draw a connection between a particular brain area and language processing was Paul Broca, a French surgeon who conducted autopsies on numerous individuals who had speaking deficiencies, and found that most of them had brain damage (or lesions) on the left frontal lobe, in an area now known as Broca's area. Phrenologists had made the claim in the early 19th century that different brain regions carried out different functions and that language was mostly controlled by the frontal regions of the brain, but Broca's research was possibly the first to offer empirical evidence for such a relationship, and has been described as "epoch-making" and "pivotal" to the fields of neurolinguistics and cognitive science. Later, Carl Wernicke, after whom Wernicke's area is named, proposed that different areas of the brain were specialized for different linguistic tasks, with Broca's area handling the motor production of speech, and Wernicke's area handling auditory speech comprehension. The work of Broca and Wernicke established the field of aphasiology and the idea that language can be studied through examining physical characteristics of the brain. Early work in aphasiology also benefited from the early twentieth-century work of KorbinianBrodmann, who "mapped" the surface of the brain, dividing it up into numbered areas based on each area'scytoarchitecture (cell structure) and function; these areas, known as Brodmann areas, are still widely used in neuroscience today.The coining of the term neurolinguistics in the late 1940s and 1950s is attributed to Edith Crowell Trager, Henri Hecaen and Alexandr Luria. Luria's book "Problems in

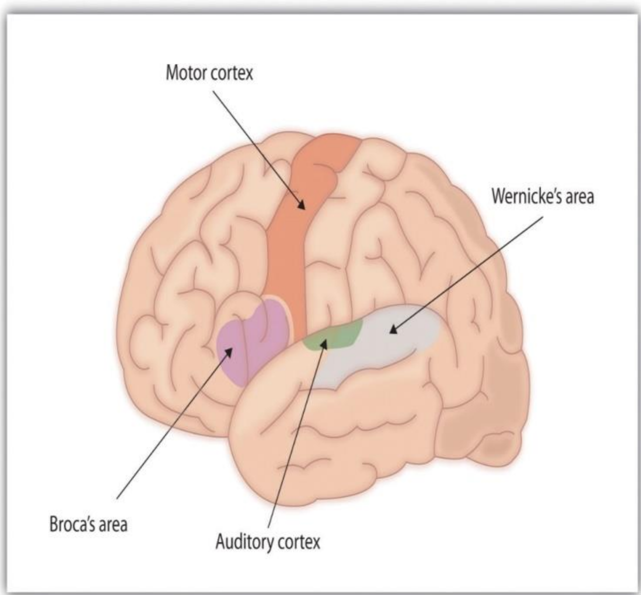
Neurolinguistics" is likely the first book with "neurolinguistics" in the title. Harry Whitaker popularized neurolinguistics in the United States in the 1970s, founding the journal "Brain and Language" in 1974.

Although aphasiology is the historical core of neurolinguistics, in recent years the field has broadened considerably, thanks in part to the emergence of new brain imaging technologies (such as PET and fMRI) and time-sensitive electrophysiological techniques (EEG and MEG), which can highlight patterns of brain activation as people engage in various language tasks. Electrophysiological techniques, in particular, emerged as a viable method for the study of language in 1980 with the discovery of the N400, a brain response shown to be sensitive to semantic issues in language comprehension. The N400 was the first language-relevant event-related potential to be identified, and since its discovery EEG and MEG have become increasingly widely used for conducting language research.

Keywords: cytoarchitecture, Brodmann, electrophysiological

The human brain

The physical seat for the representation and processing of language is hosted in the brain. A side view reveals three major divisions in the human brain: the cerebrum, which is the largest part and constitutes what is usually referred to as the “brain”; the cerebellum, which lies behind the cerebrum and is primarily a movement control center with connections with the cerebrum and the spinal cord; the brain stem, which forms the stalk from which the cerebrum and the cerebellum sprout and serves to relay information to and from the spinal cord, and to regulate vital functions such as breathing. The cerebrum is divided into two cerebral hemi-spheres (left and right) by the longitudinal fissure, connected by a band of cross fibers (corpus callosum). The surface of the hemispheres is covered with a layer of grey matter, the cerebral cortex, made up of nerve cell bodies (neurons), while the inner layer, the white matter, consists mostly of long axons. While grey matter is mainly responsible for information processing, white matter is responsible for information transmission, carrying nerve electrical signals throughout the brain and the rest of the body. Clinical and experimental evidence indicates that the cortex is the primary seat of human reasoning and cognition, including most aspects ofValentina Bambini language. Considering its prominence in the human brain, the cortex deserves further description.



Keywords: cerebrum, Valentina Bambini

The Classical model

Norman Geschwind is credited with overcoming purely behavioral explanations of cognitive processes and bringing the study of cognition back into the frame-work of neurology. He carefully reviewed the neurological literature of the 19th century and exported its insights – especially the connectionist perspective – into modern research, emphasizing the role of connective pathways between different parts of the brain (Geschwind 1965; Catani &fytche 2005). He extensively described the disconnection syndromes that follow the disruptions of the path-ways, affecting knowledge (agnosia), action (apraxia), and language (aphasia). For what concerns language, his proposal represents an extension and refinement of the classical Wernicke-Lichtheim diagram, and became popular as the Wernicke-Geschwind model. Its fortune is also linked to the so-called Boston School, a group of researchers connected to the Aphasia Research Center in Boston, strongly influenced by Geschwind's clinical studies and by Chomsky's formal and nativist approach to grammar (Goodglass& Kaplan 1983).The main claims of the (neo)classical approach to language functioning can be schematically summarized as follows:

There are two primary seats in the brain for language: Broca's area (located in the inferior frontal gyrus, corresponding to BAs 44 and 45), and Wernicke's area (located in the posterior superior temporal gyrus, roughly corresponding to BA 22 and posterior part of BA 21), which are connected through the arcuatefasciculum, a fiber tract running in the white matter; other connections link these regions with the visual and auditory systems. Each area is dedicated to a specific modality: Broca's area subserves production, Wernicke's area sub-serves comprehension. Lesions to each area lead to specific types of aphasia: Broca's aphasia and Wernicke's aphasia; disconnection of the two areas leads to conduction aphasia. A fourth claim made by the classical model follows from the tenets above, namely the lateralization of linguistic functions in the left hemisphere. Data showed that the left hemisphere is dominant for language functions in about 96% of right-handed and in 70% of left-handed adults; of the remaining left handers, half have right dominance, and half have a bilateral representation (Rasmussen & Milner 1977). Several investigations carried out since the second half Neurolinguistics of the 20th century supported the lateralization hypothesis, showing functional and structural asymmetry between the two hemispheres (Gazzaniga& Sperry 1967; Geschwind&Levitsky 1968). In this view, a stroke to the dominant hemisphere was predicted to cause an aphasic syndrome, while a lesion in the right hemisphere should not be associated with language disruptions. Apparently in contrast with this, by the end of the Seventies clinicians started to notice a number of language deficits that followed right hemisphere lesions. These defi-cits, however, although affecting language, did not fit classic aphasic classifications: first described as high-level linguistic disorders, these were later grouped under the label of pragmatic disorders (Joanette et al. 1990; Tompkins 1995). The observation of right hemisphere language deficit, thus, far from disconfirming the claim of the left hemispheric dominance for language, strengthened it as to include a pragmatic appendix: the two hemispheres were assumed to differ markedly in their importance for language functioning, with the left being responsible for standard linguistic processing, and the right housing paralinguistic and communicative-pragmatic abilities (Paradis 1998).The main tenets of the classical model, including the corollary of the right hemi-sphere for pragmatics, were radically imposed and still feature in most textbooks in neuroscience. Unquestionably, this model has been immensely useful both heuristically, to stimulate research in neurolinguistics, and clinically, to guide diagnosis. However, its assumptions have not survived the test of time and technology, at least not in the original form.

Keywords: fasciculum, aphasia, paralinguistic,

Subject task

In many neurolinguistics experiments, subjects do not simply sit and listen to or watch stimuli, but also are instructed to perform some sort of task in response to the stimuli. Subjects perform these tasks while recordings (electrophysiological or hemodynamic) are being taken, usually in order to ensure that they are paying attention to the stimuli. At least one study has suggested that the task the subject does has an effect on the brain responses and the results of the experiment.

Lexical decision
Main article: Lexical decision task
The lexical decision task involves subjects seeing or hearing an isolated word and answering whether or not it is a real word. It is frequently used in priming studies, since subjects are known to make a lexical decision more quickly if a word has been primed by a related word (as in "doctor" priming "nurse").

Grammaticality judgment, acceptability judgment
Main article: Acceptability judgment task
Many studies, especially violation-based studies, have subjects make a decision about the "acceptability" (usually grammatical acceptability or semantic acceptability) of stimuli. Such a task is often used to "ensure that subjects are reading the sentences attentively and that they distinguish acceptable from unacceptable sentences in the way the experimenter expect them to do."

Experimental evidence has shown that the instructions given to subjects in an acceptability judgment task can influence the subjects' brain responses to stimuli. One experiment showed that when subjects were instructed to judge the "acceptability" of sentences they did not show an N400 brain response (a response commonly associated with semantic processing), but that they did show that response when instructed to ignore grammatical acceptability and only judge whether or not the sentences "made sense".

Probe verification

Some studies use a "probe verification" task rather than an overt acceptability judgment; in this paradigm, each experimental sentence is followed by a "probe word", and subjects must answer whether or not the probe word had appeared in the sentence. This task, like the acceptability judgment task, ensures that subjects are reading or listening attentively, but may avoid some of the additional processing demands of acceptability judgments, and may be used no matter what type of violation is being presented in the study.

Truth-value judgment

Subjects may be instructed not to judge whether or not the sentence is grammatically acceptable or logical, but whether the proposition expressed by the sentence is true or false. This task is commonly used in psycholinguistic studies of child language.

Active distraction and double-task

Some experiments give subjects a "distractor" task to ensure that subjects are not consciously paying attention to the experimental stimuli; this may be done to test whether a certain computation in the brain is carried out automatically, regardless of whether the subject devotes attentional resources to it. For example, one study had subjects listen to non-linguistic tones (long beeps and buzzes) in one ear and speech in the other ear, and instructed subjects to press a button when they perceived a change in the tone; this supposedly caused subjects not to pay explicit attention to grammatical violations in the speech stimuli. The subjects showed a mismatch response (MMN) anyway, suggesting that the processing of the grammatical errors was happening automatically, regardless of attention or at least that subjects were unable to consciously separate their attention from the speech stimuli.

Another related form of experiment is the double-task experiment, in which a subject must perform an extra task (such as sequential finger-tapping or articulating nonsense syllables) while responding to linguistic stimuli; this kind of experiment has been used to investigate the use of working memory in language processing.

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